To Live and Die in a Turbulent Era

Bioarchaeological Analysis of the Early Byzantine (6th–7th centuries AD) Population from Sourtara Galaniou Kozanis (Northern Greece)

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Teeth and bones serve as the primary source of evidence for anthropological and paleopathological analysis. In the last decade it has come to be well understood that the combination of cultural and biological data (bioarchaeology) offers the most holistic reconstruction of human life and activity in the past.[1] Moreover, scholars have shown increased interest in bioarchaeological studies of Byzantine populations from Greece, since such interdisciplinary approaches shed more light on the past, especially on turbulent periods, such as the early Byzantine.[2]

Archaeological and documentary evidence on the early Byzantine period suggests that it was in general a transitional and idiosyncratic era marked by dramatic historical, social, economic, and environmental changes.[3] Early Byzantines suffered invasions, earthquakes, and the social upheavals associated with the introduction of Christianity.[4] The picture for northern Greece, and especially for Greek Macedonia—a highly strategic region of the Byzantine Empire—is quite similar.[5] Most of our knowledge regarding the area derives from rescue excavations, surveys, and catalogues of scattered material. These sources provide important information on religious edifices, settlements, and

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1 C. S. Larsen, *Bioarchaeology: Interpreting Behavior from the Human Skeleton* (Cambridge, 1997); J. E. Buikstra, "Preface," in *Bioarchaeology: The Contextual Analysis of Human Remains,* ed. J. E. Buikstra and L. A. Beck (Amsterdam, 2006), xvii–xx.

2 To date, the only fully published early Byzantine site is Eleutherna in Crete. Prof. Petros Themelis supervised the publication of four distinct volumes dedicated to years of systematic field work (1986–2003) at Eleutherna. See P. Themelis, ed., *Πρωτοβυζαντινή Ελεύθερνα,* vol. 1, pt. 2 (Athens, 2000); idem, ed., *Πρωτοβυζαντινή Ελεύθερνα,* vol. 1, pt. 1 (Athens, 2004); C. Bourbou, *The People of Early Byzantine Eleutherna and Messene (6th–7th centuries AD): A Bioarchaeological Approach* (Athens, 2004); A. Yangaki, *La céramique des IV^e–VII^e siècles ap. J.-C. d'Eleutherna* (Athens, 2005).

3 For a thorough discussion on the historical and archaeological context of the early Byzantine era, see Bourbou, *People,* 59–62.

4 C. Mango, *Byzantium: The Empire of New Rome* (London, 1980); Av. Cameron, *The Mediterranean World in Late Antiquity, AD 395–600* (London, 1993); G. B. Bowersock, P. Brown, and O. Grabar, *Interpreting Late Antiquity: Essays on the Postclassical World* (Cambridge, 2001).

5 F. Karagianni, "Οι βυζαντινοί οικισμοί στη Μακεδονία μέσα από τα αρχαιολογικά δεδομένα" (PhD diss., Aristotle University of Thessalonike, 1999); A. Konstantakopoulou, "Ιστορική γεωγραφία της Μακεδονίας" (PhD diss., University of Ioannina, 1984); T. Loungis, "Η εξέλιξη της βυζαντινής πόλης από τον τέταρτο στο δωδέκατο αιώνα," *Βυζαντινιακά* 16 (1966): 33–67.

defensive works.[6] From the third century AD onward, the region suffered from extensive invasions and settlements by various groups (e.g., the Goths and later the Slavs). It was only during the sixth century AD that the Byzantine Empire, under the rule of Justinian, applied an extended plan of restoration and reinforcement of vulnerable areas through the building of defensive settlements. This did not have a lasting effect. During the sixth–eighth centuries AD, further invasions and natural disasters resulted in the abandonment of numerous sites, some of which were repopulated when the danger diminished. The excavation of the early Byzantine cemetery at Sourtara Galaniou Kozanis suggests the existence of a hitherto unknown early Byzantine settlement in a strategic position along the road connecting the upper and lower parts of Greek Macedonia, in an area generally unexplored for its Byzantine occupation.

In this study I present the results of the analysis of forty-four individuals retrieved from Sourtara.[7] The primary focus of this research is to provide information on specific pathological conditions that suggest evidence of physiological disruption (stress) during a turbulent era of Greek history, and the impact of these constraints on specific age groups, such as non-adults.[8]

Materials and Methods

During the 1998–1999 rescue excavations along the national road of Egnatia, at the section between the areas of Kozani and Polymylos (6 km SW of the current settlement of Ayios Dimitrios, and 4 km NW of the settlement of Koilada), an early Byzantine cemetery was discovered at Sourtara Galaniou, in the prefecture of Kozani (fig. 1). One hundred and nineteen single inhumations in simple pit graves were excavated. Occasionally, artifacts associated with the interment (e.g., fragments of wooden coffins or carriers), or features associated with burial ceremonies (e.g., hearths for the preparation of ceremonial feasts) were found. The typology of the few, and generally poor, accompanying grave goods enable us to date the cemetery to the sixth–seventh centuries AD.[9]

The human remains of this study are generally poorly preserved. Adult age at death was estimated using the pubic symphysis and the auricular surface. Sex was determined in adults using dimorphic aspects of the pelvis and skull.[10] Age was estimated in non-adults by dental eruption and development, as well as by long bone length.[11] No attempt was made to determine sex in immature individuals. It was impossible to estimate the stature of the adult individuals, since most long bones were fragmentary.

My study focuses on the impact of stress on the health status of the population.[12] Physiological

6 A. D. Keramopoulos, "Ανασκαφαί και έρευναι εν τη άνω Μακεδονία," *ΠΑΕ* (1932): 81–87, 96–97, 99–100, 113–14; idem, "Ανασκαφαί και έρευναι εν τη άνω Μακεδονία," *ΠΑΕ* (1933a): 25–67; idem, "Έρευναι εν Δυτική Μακεδονία," *ΠΑΕ* (1933b): 63–65; idem, "Ανασκαφαί και έρευναι εν τη άνω Μακεδονία," *ΠΑΕ* (1934): 87–89; idem, "Ανασκαφαί και έρευναι εν τη άνω Μακεδονία," *ΠΑΕ* (1937): 71–72; M. Michaelidis, "Μακεδονία," *Ἀρχ.Δελτ.* 20 (1965): 475, table 598; idem, "Μακεδονία-Θράκη," *Ἀρχ.Δελτ.* 26 (1971): 446–47; S. Pelekanidis, "Μακεδονία," *Ἀρχ.Δελτ.* 16 (1960): 227–28, table 450; E. Tsigaridas and A. Loverdou-Tsigarida, "Αρχαιολογικές Έρευνες στο Βελβεντό Κοζάνης," *Μακεδονικά* 22 (1982): 302–28; A. Tsilipakou, "Σέρβια Κοζάνης," *Ἀρχ.Δελτ.* 50 (1995): 609–11, table 184α–β; eadem, "Σέρβια Κοζάνης," *Ἀρχ.Δελτ.* 52 (1997): 814–20.

7 The total number of skeletons available for analysis is 115. I studied the first part of the collection (71 skeletons) with funding received by the Wiener Laboratory (J. Lawrence Angel Fellowship 2001–2002); see C. Bourbou and A. Tsilipakou, "Investigating the Human Past of Greece during the 6th–7th Centuries AD: Patterns of Life and Death at the Site of Sourtara Galaniou Kozanis in Northern Greece," in *New Directions in the Skeletal Biology of Greece*, ed. L. Schepartz, S. Fox, and C. Bourbou, Occasional Wiener Laboratory Series 1, Hesperia Supplement vol. 43 (Princeton, 2009), 121–36. The analysis of the 44 skeletons presented here has been carried out with additional funding received from Dumbarton Oaks (Project Grant 2006–2007).

8 The term "non-adult" encompasses all children recovered at the site up to the age of 17 years. It is suggested by Mary Lewis as the most appropriate term for ease of reference and as a biological basis of discussion and further comparative analysis rather than as a descriptive term of the complex social and cultural status of the child in any society; see M. Lewis, *The Bioarchaeology of Children* (Cambridge, 2007), 2.

9 A. Tsilipakou, "Σουρτάρα Γαλανίου Κοζάνης," *Ἀρχ.Δελτ.* 53 (1998): 714; eadem, "Σουρτάρα Γαλανίου Κοζάνης," *Ἀρχ.Δελτ.* (forthcoming); A. Petkos, "Ἀρχαιολογικές έρευνες στην περιοχή αρμοδιότητας της 11ης ΕΒΑ, στον άξονα της Ἐγνατίας οδού," in *Πρακτικά της Ἀρχαιολογικής Συνάντησης Ἐργασίας "Ἀρχαιολογικές Ἔρευνες και Μεγάλα Δημόσια Ἔργα"* (Thessalonike, 2004), 156–57.

10 Criteria for adult age and sex estimation after J. E. Buikstra and D. H. Ubelaker, *Standards for Data Collection from Human Skeletal Remains* (Fayetteville, 1994).

11 Criteria for non-adult age estimation after L. Scheuer and S. Black, *Developmental Juvenile Osteology* (San Diego, 2000); D. H. Ubelaker, *Human Skeletal Remains* (Washington, DC, 1989).

12 A. H. Goodman et al., "Biocultural Perspectives on Stress in Prehistoric, Historical and Contemporary Population Research," *Yearbook of American Journal of Physical Anthropology* 31 (1988): 169–202.

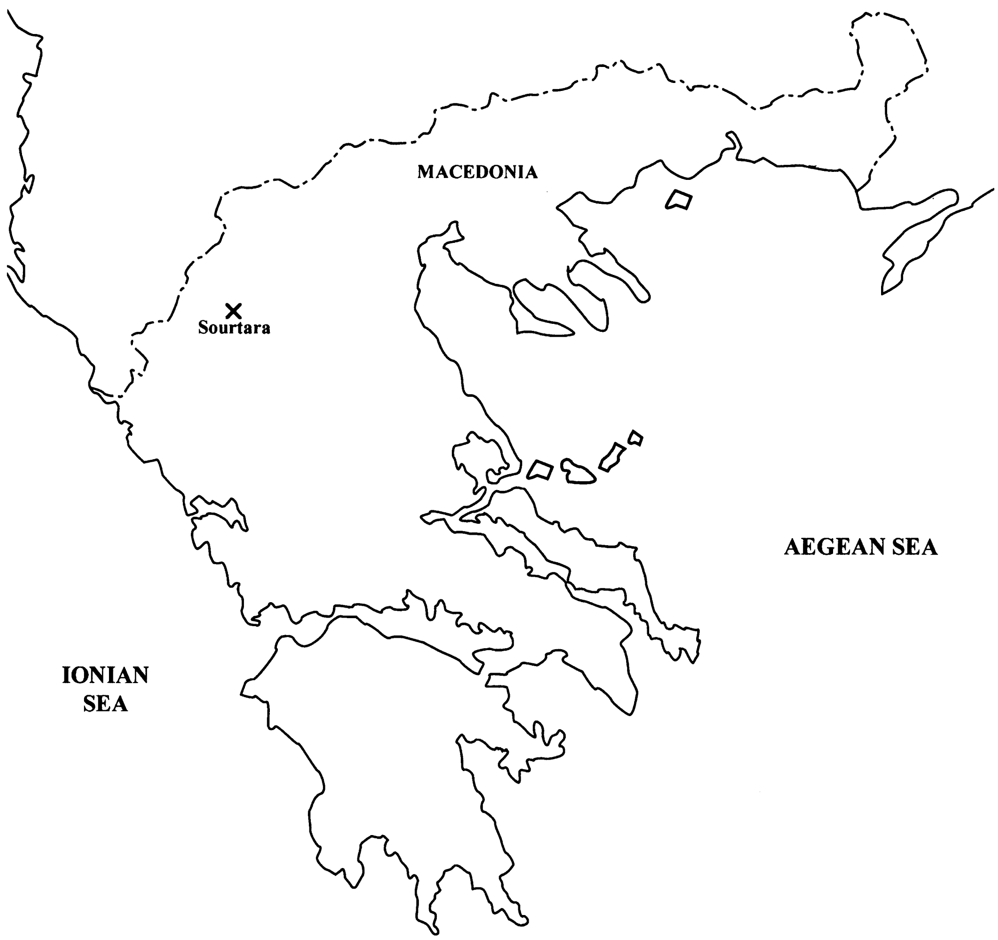


FIG. 1 Map showing location of the Sourtara Galaniou Kozanis site

disruption (stress) resulting from impoverished environmental and social conditions is central to the study of health in past populations. Stress is a product of three key factors: environmental constraints, cultural systems, and host resistance. To test how individuals were affected by social and environmental changes, the collection was analyzed for the presence of dental diseases,[13] metabolic and hematopoietic disorders,[14] degenerative joint diseases (DJD),[15] and infections. The adult individuals are grouped in the following age categories: 18–30 years (young adults), 31–40 years (middle adults), 41–50 years (mature adults), and 51 years of age and over (old adults). In order to delineate the role played by sanitary, social, and other environmental conditions in non-adult mortality and survival, two age groups have been constructed: after birth–4 years and 5–9 years old.

13 Criteria after D. R. Brothwell, *Digging Up Bones* (Oxford, 1981); J. R. Lukacs, "Dental Palaeopathology: Methods for Reconstructing Dietary Patterns," in *Reconstruction of Life from the Skeleton*, ed. M. Y. İşcan and K. A. R. Kennedy (New York, 1989), 261–86.

14 Criteria after P. Stuart-Macadam, "Anemia in Roman Britain: Poundbury Camp," in *Health in Past Societies: Biocultural Interpretations of Human Skeletal Remains in Archaeological Contexts*, ed. H. Bush and M. Zvelebil, BAR 567 (Oxford, 1991), 101–13; D. Ortner, *Identification of Pathological Conditions in Human Skeletal Remains* (San Diego, 2003).

15 Criteria after J. Rogers and T. Waldron, *A Field Guide to Joint Disease in Archaeology* (Chichester, 1995); J. Rogers et al., "Arthropathies in Paleopathology: The Basis of Classification According to Most Probable Cause," *Journal of Archaeological Science* 17 (1987): 179–93.

TABLE 1a. Dental disease in the adult sample (individuals affected)

Individuals	Individuals affected	M	F	I	CPR (%)*
25	18	12	3	3	72.0

M = male, F = female, I = indeterminate
*CPR = Crude Prevalence Rate. This represents the percentage of individuals in the sample with dental disease.

TABLE 1b. Dental disease in the adult sample (teeth affected)

Dental pathology	Teeth affected	TPR (%)*
Antemortem tooth loss	64	39.7
Caries	13	8.0
Calculus	23	14.2
Enamel hypoplasia	8	4.9
Attrition	15	9.3
Abscess	1	0.6
Total	*124*	*77.0*

*TPR = True Prevalence Rate. This represents the percentage of teeth in the sample (161 teeth) affected by a pathological condition.

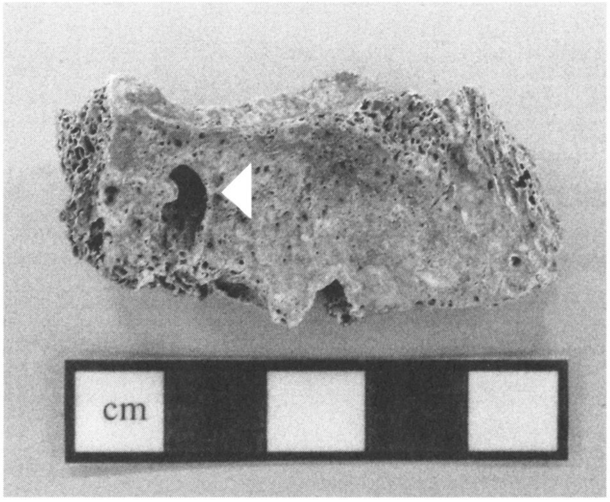
Results

Of the forty-four individuals that make up the sample of this study, determination of sex was possible for 17 (13 males and 4 females), while the sex of 27 remains unknown (19 were non-adults). The average age at death for males is ca. 42 years, and for females is ca. 35 years.

Dental disease

Data on dental disease in the adult sample (N = 25) are presented in Tables 1a and 1b. The true prevalence rate of dental disease is 77% (124 out of 161 teeth). The most striking pathological condition is antemortem tooth loss,[16] 64 teeth, or 39.7%, followed by calculus (tartar), 23 teeth, or 14.2%, and carious lesions (cavities), 13 teeth, or 8%. Most dental disease is observed in the age group 40–50 years old, and males are more affected than females (n = 12 males, or 48%; n = 3 females, or 12%). The fragmentary preserved maxilla of skeleton 83 demonstrates alveolar resorption in the region over the left canine tooth. Postmortem damage in the area revealed a barely visible dental element, slightly projecting through the bone; the radiograph of the maxilla showed that it is an impacted canine. The heterotopic tooth (meaning a tooth developed outside of the alveolar region) is fully formed. It is common for one or more teeth to become impacted and fail to erupt due to insufficient room; this impaction, however, led to the formation of the alveolar resorption (figs. 2a–b).

16 Loss of teeth before death. In the sample, two edentulous mandibles have been observed.



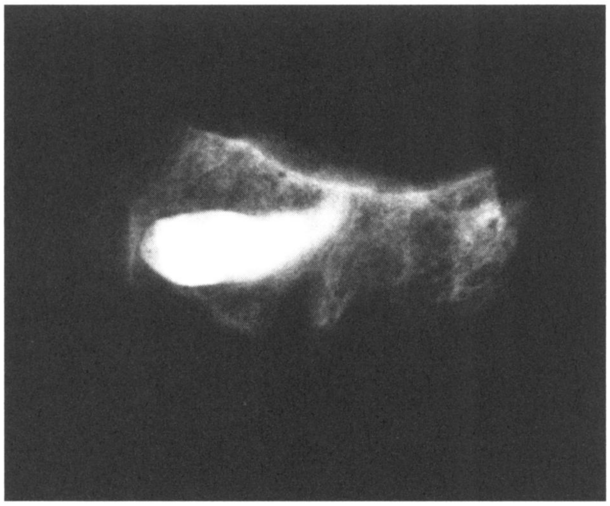


FIG. 2 Skeleton 083. Impacted left maxillary canine: (a) posterior view (arrow shows possible abscess); (b) radiograph of the maxilla

Hematopoietic and metabolic disorders

Tables 2a and 2b present the hematopoietic disorders in the sample (N = 44). Cribra orbitalia and porotic hyperostosis are the most commonly observed skeletal lesions, and non-adult individuals exhibit the most active and severe cases. The true prevalence rate of cribra orbitalia is 25% (6 affected orbits out of 24), and the rate of porotic hyperostosis is 1.4% (4 affected parietal bones out of 267).[17] Cribra orbitalia is observed on the right eye orbit of skeleton 71 (ca. 18 years of age), on the left eye orbit of skeleton 77 (male, 44 years old), skeleton 83 (male, 50 years old), and skeleton 105 (ca. 1.5 years old; fig. 3), and on both eye orbits of skeleton 87 (8–9 years old). Porotic hyperostosis is observed in all preserved cranial fragments of skeleton 102 (ca. 2 years old; fig. 4). On the exterior, the fragments exhibit distinctive porosity; there is also widening of the inner diploë.[18]

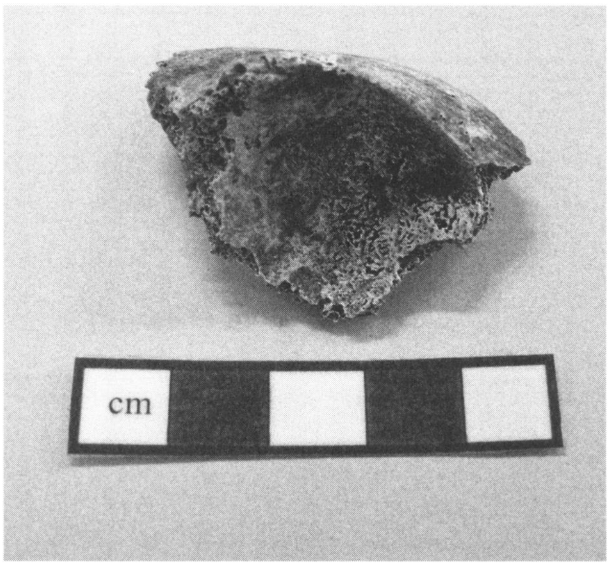


FIG. 3 Skeleton 105. Severe cribra orbitalia on left eye orbit

17 The term "cribra orbitalia" refers to porous lesions on the orbital roof which are thought to be associated with similar lesions on the cranial vault known as "porotic hyperostosis." These lesions result from an over-activity of the marrow, a thinning of the outer table of the skull, widening of the inner diploe, and a speculated "hair-on-end" appearance of the trabecular structure.

18 The diploë is the soft spongy material between the interior and exterior bony plates of the skull. It contains bone marrow.

TABLE 2a. Hematopoietic disorders in the sample (individuals affected)

Hematopoietic disorder	Total no. of individuals affected	M	F	NA	CPR (%)*
Cribra orbitalia	5	3	0	2	11.0
Porotic hyperostosis	1	0	0	1	2.0
Total	*6*	*3*	*0*	*3*	*14.0*

M = male, F = female, NA = non-adult
* The percentage of individuals in the entire sample (44) affected by a hematopoietic disorder.

Table 2b. Hematopoietic disorders in the sample (bones affected)

Hematopoietic disorder	Cranial bones observed	Cranial bones affected	TPR (%)
Cribra orbitalia	24*	6	25.0
Porotic hyperostosis	267**	4	1.0
Total	*291*	*10*	*3.0*

* orbits
** parietals (only countable fragments)

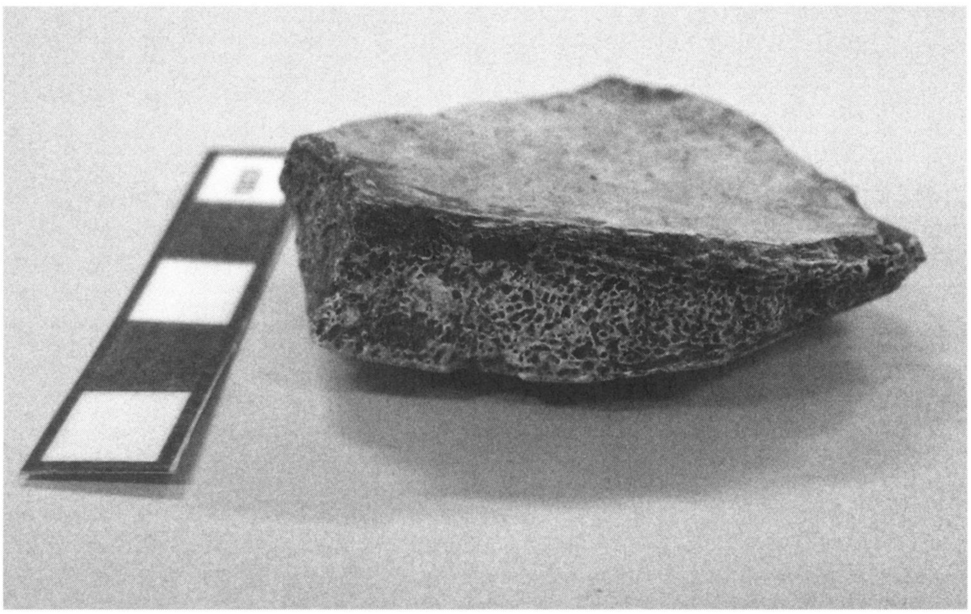


FIG. 4 Skeleton 102. Porotic hyperostosis of a frontal fragment; note extreme widening of the inner diploë

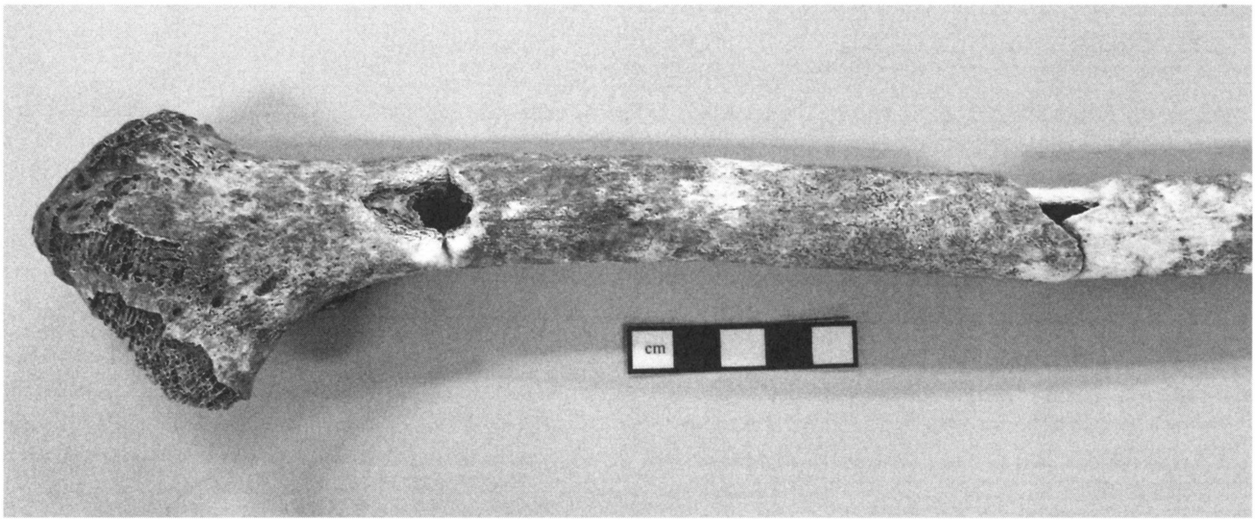


FIG. 5 Skeleton 96. Anterolateral bending of the proximal third of the femoral shaft, possibly indicating vitamin D deficiency

The long bones of skeleton 96 (male, 18–25 years old), albeit fragmentarily preserved, exhibit prominent anterolateral bending, mainly of the ulnae and radii of the upper limbs and femora and tibiae of the lower limbs. It is suggested that this abnormal bowing of the long bones may be associated with vitamin D deficiency (fig. 5).

Degenerative Joint Disease

The cases of osteoarthritis observed on the joints of the upper and lower limbs of the adult individuals (N = 25) are tabulated in Tables 3a and 3b. The true prevalence rate is 9.8% or 12 affected joints out of 122. Most cases of osteoarthritis in the upper and lower limbs are observed in mature and old adult individuals (41–50 years and older). Males are more affected than females (n = 4 males, or 16% and n = 1 female, or 4%).

Skeleton 77 exhibits osteoarthritis (osteophytes, porosity, and slight eburnation) of the wrist joint.[19] Two carpal bones exhibit degenerative lesions on the scaphoid tubercle (adjacent to the hollowed capitate facet, which had no changes) and the base of trapezoid (adjacent to the articular facets for trapezium—not present—and scaphoid). Skeleton 83 presents osteoarthritis of the glenohumeral joint (shoulder joint); osteophytosis and porosity are visible on the right glenoid of the scapula. Due to the fragmentation of the associated humerus, no degenerative changes could be observed on the head. Skeleton 95 presents multiple osteoarthritic changes on the right glenohumeral joint (osteophytes and porosity on the glenoid of the scapula and on the head of the associated humerus), on the right wrist joint (marginal osteophytes on the distal end of the ulna), and on both knee joints (fig. 6). Both tibial plateaus exhibited marginal osteophytes and porosity; slight eburnation is visible on the medial condyle of the left tibia. Despite fragmentation of both distal femoral ends, some osteophytic formation and porosity can be traced. The first proximal foot phalanx of skeleton 96 exhibits osteoarthritis of the metatarsophalangeal joint; osteophytes and marked porosity are present on the base. Finally, skeleton 98 demonstrates

19 Osteoarthritis affects the synovial joints. The typical set of diagnostic criteria on dry bone includes the presence of osteophytes, areas of porosity or pitting, alteration of the bony contour of the joint, and the most unequivocal marker of the condition, eburnation. Osteophytes are bony outgrowths that frequently occur at the margins of articular surfaces; eburnation refers to a polished joint surface that develops when a joint continues to be used after the cartilage protecting it has been destroyed.

TABLE 3a. Osteoarthritis of the appendicular skeleton in the adult sample (individuals affected)

	Individuals affected		
Joints affected	M	F	CPR (%)
One	3	1	16.0
Two or more	1	0	4.0

M = male, F = female

Table 3b. Osteoarthritis in the adult sample (joints affected)

Joint	**Joints observed**	**Joints affected**	**TPR (%)**
Glenohumeral	58	3	5.1
Wrist	28	2	7.1
Hand	7	2	28.5
Knee	28	4	14.2
Foot	1	1	100
Total	*122*	*12*	*9.8*

TABLE 4a. Degenerative disease of the spine in the adult sample (individuals affected)

Individuals	**Individuals affected**	**M**	**F**	**I**	**CPR (%)**
25	10	7	2	1	40.0

M = male, F = female, I = indeterminate

TABLE 4b. Degenerative disease of the spine in the adult sample (vertebrae affected)

Degenerative disease	**Vertebrae affected**	**TPR (%)***
Osteoarthritis	4	1.7
Spondylosis	69	29.3
Schmorl's nodes	17	7.2
Discal prolapse	3	1.2
Total	*93*	*39.5*

M = male, F = female

* TPR calculated using a total of 235 observed vertebrae in the sample.

FIG. 6 Skeleton 95. Osteoarthritis of the knee joint. Degenerative changes are visible on the tibial plateau

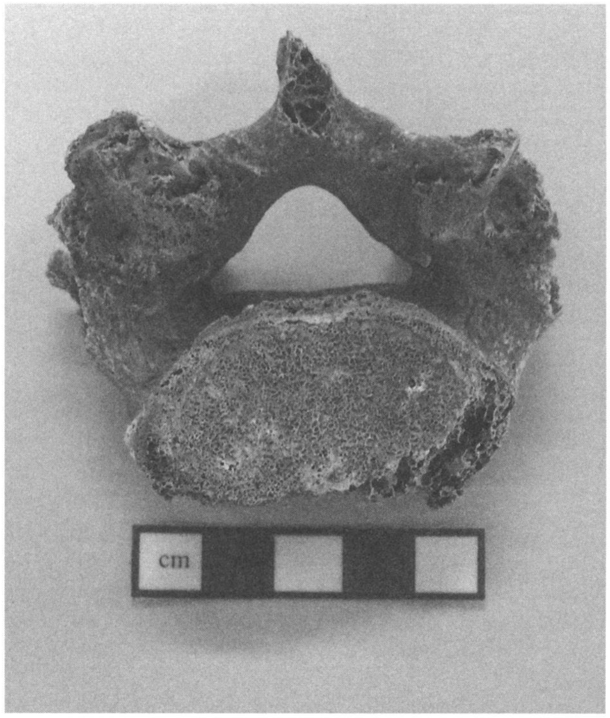


FIG. 7 Skeleton 97. Osteoarthritis of the spine. Osteophytes, porosity, and slight eburnation are visible on the inferior spinous processes of a lumbar vertebra

osteoarthritis of the wrist joint; the distal end of the left radius presents marginal osteophytes and porosity.

Tables 4a and 4b present degenerative disease of the spine in the adult sample (N = 25). Among a total of 235 vertebrae, the true prevalence rate of osteoarthritis is 1.7% (4 affected lumbar vertebrae),[20] and and the rate of spondylosis[21] is 29.3% (69 affected vertebrae: 14 cervical, 36 thoracic, and 19 lumbar). The true prevalence rate of Schmorl's nodes is 7.2% (17 affected vertebrae: 16 thoracic and 1 lumbar), and the rate of discal prolapse (depression on the vertebral body protruding into the spinal cord) is 1.2% (3 affected thoracic vertebrae). In all observable degenerative disease of the spine, males (n = 7, or 28%) are more frequently affected than females (n = 2, or 8%).

Infectious conditions

Skeleton 87 exhibited a periosteal reaction in the form of woven bone on the left interior mandibular ramus. The lesion extends from above the mandibular foramen to the interior of the tooth socket. However, the observed new bone formation cannot be diagnosed as pathological, since it may be related to the active growth in the tooth socket's area. Skeleton 88 presents a very interesting case. The right tibial shaft exhibits extreme thickening and a cloaca on the distal end of the anterior/lateral aspect with marginal porous activity. It is clearly enlarged when compared to the normal left tibia (fig. 8). The presence of a cloaca suggests an osteomyelitic case. The radiograph of the bone enabled us to detect a possible fracture line (greenstick fracture?) and Harris lines on the proximal end of the shaft (fig. 9).[22]

20 Osteophytes, porosity, and eburnation visible on the spinous processes of the vertebrae.

21 Marginal osteophytes and porosity visible on the vertebral bodies.

22 Harris lines are transverse lines of radiodensity at the ends of long bones; for a review see A. Aufderheide and C. Rodriguez-Martin, *The Cambridge Encyclopedia of Human Paleopathology* (Cambridge, 1998), 422. Harris lines are considered a popular

FIG. 8 Skeleton 88. Osteomyelitis of the right tibial shaft (arrow pointing to a cloaca) in comparison with the normal bone

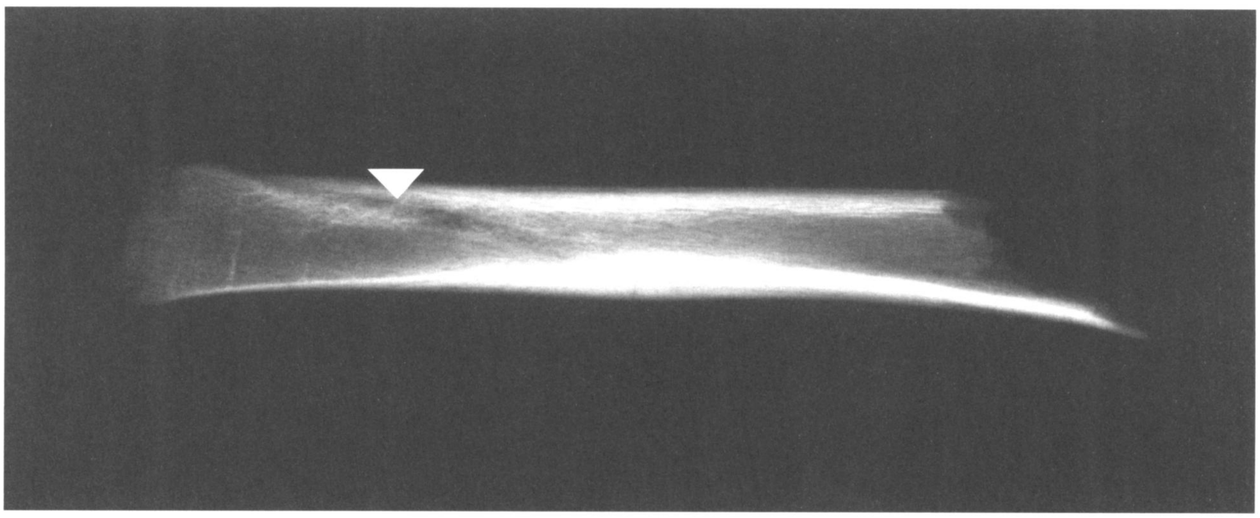


FIG. 9 Skeleton 88. Radiograph of the affected bone demonstrating possible fracture line. Radiograph also revealed the presence of Harris lines

Varia

Aneurysmal erosion?

Skeleton 98 presented an oval depression on the right first rib. Initially, it was thought to indicate a possible traumatic incident, but the radiograph showed no evidence of fracture. It is suggested that this depression could represent a case of aneurysmal erosion.

Conclusions

Notwithstanding the hardships of the period, the mean age at death at Sourtara appears to have been considerably higher than in the preceding centuries, since, for example, in the Roman Imperial period, the average life expectancy is estimated at 38.8 years for males and 34.2 years for females.[23] As shown in Table 5, values for mean age at death for the Sourtara sample do not vary considerably from other sites dating to the same time period.

Despite the generally poor preservation of the collection, non-adult individuals (n = 19, or 43%) are not underrepresented, as is often the case in cemetery populations.[24] Little difference is noted in the number of non-adult deaths in the age groups birth to 4 years and 5 to 9 years, while mortality rates seem to decline after age 10.[25] The high rate of non-adult deaths in the age group 5–9 years old may be largely rooted in environmental and cultural factors, such as poor sanitation and nutrition. If living conditions were poor and thus hindered a rapid recovery from diseases or other stresses, all children were likely at risk, especially those who had already endured the usual episodes of stress during their early years.

Cultural factors influencing dietary choices cannot be ruled out as a possible explanation for the differences in mortality rates seen in the non-adult individuals of this population. Such cultural factors may include differences in weaning practices and in the selection of dietary elements, as well as in the proportions of those elements. The available stable isotope data for Greek Byzantine-era populations suggest very tentatively that weaning was a gradual process for these groups, perhaps terminating around the age of three years. These findings are in general agreement with the recommendations of ancient and early Byzantine physicians.[26] Weaning and, in particular, the quality of the supplementary food may coincide with the development of specific and nonspecific pathological conditions.[27]

Some general assumptions can be drawn regarding the pathological lesions observed in the individuals of the sample. First, the high incidence of dental pathologies suggests a diet rich in sugar and carbohydrates. Cribra orbitalia and porotic hyperostosis have become synonymous over the years with iron-deficiency anemia.[28] However, one must bear in mind that their etiology is not always so clear-cut, and they are better viewed as descriptive, rather than diagnostic terms.[29]

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indicator of physiological stress in ancient populations, but are problematic on account of the interpretation of their etiology and limitations associated with the recording of these features (for a discussion, see Lewis, *Bioarchaeology of Children* [n. 8 above], 107–11).

23 S. C. Bisel and J. L. Angel, "Health and Nutrition in Mycenean Greece," in *Contributions to Aegean Archaeology*, ed. N. C. Wilkie and W. D. E. Coulson (Minneapolis, 1985), 197–210, table 4.

24 For an extensive overview of the factors affecting the preservation of non-adult remains, see Lewis, *Bioarchaeology of Children*, 20–37.

25 It is commonly assumed that the highest proportion of deaths would be among the newborns in any mortality sample. For a thorough discussion see D. J. P. Barker, "Fetal Growth and Adult Disease," *British Journal of Obstetrics and Gynaecology* 99 (1992): 275–82; D. J. P. Barker and C. Osmond, "Childhood Respiratory Infection and Adult Chronic Bronchitis in England and Wales," *British Medical Journal* 239 (1986): 1271–75; D. J. P. Barker and C. N. Martyn, "The Maternal and Fetal Origins of Cardiovascular Disease," *Journal of Epidemiology and Community Health* 46 (1992): 8–11.

26 For preliminary results on breastfeeding and weaning patterns in Greek Byzantine populations and associated documentary evidence, see C. Bourbou and S. Garvie-Lok, "Breastfeeding and Weaning Patterns in Byzantine Times: Evidence from Human Remains and Written Sources," in *Becoming Byzantine: Children and Childhood in Byzantium*, ed. A. Papaconstantinou and A.-M. Talbot (Washington, DC, 2009), 65–83.

27 For an up-to-date discussion on breastfeeding and weaning, see Lewis, *Bioarchaeology of Children* (n. 8 above), 97–100, 115–19.

28 For a discussion of the iron bioavailability in different sources, see R. D. Baynes and T. H. Brothwell, "Iron Deficiency," *Annual Revue of Nutrition* 10 (1990): 133–48. For the contribution of various nondietary factors to the development of the condition, see P. Stuart-Macadam, "Nutritional Deficiency Disease: A Survey of Scurvy, Rickets and Iron-Deficiency Anemia," in İşcan and Kennedy, *Reconstruction of Life from the Skeleton*, 201–22.

29 For a thorough discussion on anemias, see Ortner, *Identification of Pathological Conditions* (n. 14 above), 363–75; Lewis, *Bioarchaeology of Children*, 111–15.

TABLE 5. Data on human skeletal collections from early Byzantine sites in Greece

	Individuals				Average age at death		Average height (cm)	
Site	M	F	I	*Total*	M	F	M	F
Sourtara	13	4	27	*44*	42	35	—	—
Eleutherna[a]	52	21	78	*151*	40–45	30–35	169	160
Messene[a]	23	12	39	*74*	45	35	170	152
Gortyn[b]	18	16	20	*54*	41	34	173	160
Knossos[c]	9	12	10	*35–50*	—*		161–178	150–162
Corinth (Lerna)[d]	54	43	67	*164*	—**		163–173	160
Abdera (Polystylo)[e]	16	5	19	*40*	—***		168	156
Thassos (Aliki II)[f]	22	1	124	*147*	40–50	30–40	162	150

M = male, F = female, I = indeterminate
* 46% died between ages 18 and 35
** 6 individuals reached the fifth decade of life
*** Nobody over 60

[a] C. Bourbou, "Health Patterns of Proto-Byzantine Populations (6th–7th Centuries AD) in South Greece: The Cases of Eleutherna (Crete) and Messene (Peloponnese)," *International Journal of Osteoarchaeology* 13 (2003): 303–13; C. Bourbou, *The People of Early Byzantine Eleutherna and Messene (6th–7th centuries A.D.): A Bioarchaeological Approach* (Athens, 2004).
[b] F. Mallegni, "Analisi dei resti scheletrici umani," in *Gortina I*, ed. A. di Vita (Rome, 1988), 339–401.
[c] J. H. Musgrave, "Anthropological Assessment," in "An Early Christian Osteotheke at Knossos," ed. H. W. Catling and D. Smyth, *BSA* 71 (1976): 25–47.
[d] A. Wesolowsky, "The Skeletons of Lerna Hollow," *Hesperia* 42 (1973): 340–51.
[e] An. Agelarakis and Ar. Agelarakis, "The Paleopathological Evidence at Polystylon, Abdera," *ByzF* 14 (1989): 9–25.
[f] J. L. Buchet and J.-P. Sodini, "Les tombes," in *Aliki II: La Basilique double*, ed. J.-P. Sodini and K. Kolokotsas (Athens, 1984), 213–43.

Skeleton 102 possibly represents the most convincing case of iron-deficiency anemia. As described above, all preserved cranial fragments exhibited widening of the inner diploë. During childhood, the diploë contains red bone marrow; an expansion of this space is thought to result from the need of the body to produce and store more red blood cells because of anemia.

Regarding metabolic disorders, a possible case of vitamin D defiency is also recorded. Vitamin D is a prohormone that is essential for adequate mineralization of newly formed bone (osteoid). A combination of dietary deficiency and lack of exposure to sunlight is one of the most common causes of vitamin D deficiency. Other causes include intestinal malabsorption and generally resistant forms of vitamin deficiency.[30]

30 For a thorough review of vitamin D metabolism and deficiency, see Ortner, *Identification of Pathological Conditions,* 393; M. Brickley, S. Mays, and R. Ives, "Skeletal Manifestations of Vitamin D Deficiency Osteomalacia in Documented Historical Collections," *International Journal of Osteoarchaeology* 15 (2005): 389–403; eidem, "An Investigation of Skeletal Indicators of Vitamin D Deficiency in Adults: Effective Markers for Interpreting Past

Cases of vitamin D deficiency in adults (referred to as osteomalacia) are rare in the paleopathological record, and only recently have the criteria been established that will facilitate the identification of this condition in archaeological remains of human bone.[31] The search for these criteria on skeleton 96 revealed only anterolateral bending of the proximal third of the femoral shaft—a consistent feature of the condition—as a result of softened bone yielding under the body's weight.

Such anterolateral bending is also a feature of childhood rickets; therefore, its presence could also be a manifestation of residual rickets in adulthood.[32] An adult bearing defects of vitamin D deficiency retained from childhood may suffer the deficiency again during adulthood and acquire the traits of osteomalacia as well as those from residual juvenile changes. Therefore, when long bone bending deformities are present, it may be difficult to differentiate between residual rickets and osteomalacia. However, in our case, the absence of pathognomonic features for osteomalacia, such as pseudofractures of the femoral neck and sub-trochanteric region, and the relative youth of the individual (18–25 years), may be indicative of residual rickets in adulthood.

Osteomyelitis is most often the result of the introduction of pyogenic bacteria into the bone. The infectious agents may reach the skeleton by several different routes: by direct infection through traumatic or surgical wounds; by direct extension from adjacent soft tissue infection; or by a hematogenous route from a remote septic focus. The causative organism in close to ninety percent of cases is *Staphylococcus aureus*; the second most frequent is *Streptococcus*.[33] In children, the indirect spread of infection through the bloodstream is most common. Generally the infection spreads into a single bone, but in twenty percent of cases it will affect multiple bones.[34] However, it is highly probable that in skeleton 88 the infectious agents reached the skeleton through a traumatic incident, a possible greenstick fracture on the tibial shaft visible on the radiograph (fig. 9). Lack of treatment, generally poor living conditions, and nutritional status may also have played a role in the deterioration of the health status and consequent death of this individual.

It is clear from the skeletal data that adult males in Sourtara have frequencies of degenerative joint diseases substantially higher than adult females. In addition, the data suggest that physiological wear and tear on joints was due to advanced age more than to other factors. In their paper, Weiss and Jurmain stress the multifactorial etiology of osteoarthritis.[35] While age is the main cause of the onset and severity of osteoarthritis, genetic influences must be also considered. On the other hand, sex differences may be a consequence of hormones, body size, and anatomy, rather than of activity.

Schmorl's nodes are frequently observed in archaeological populations, regardless of temporal and regional context or of subsistence strategy. The presence of Schmorl's nodes and discal prolapse in our sample is most probably caused by degenerative changes associated with repetitive stress on the vertebral column. Faccia and Williams investigated the relationship between Schmorl's nodes and pain, demonstrating that centrally located Schmorl's nodes are significantly correlated with pain.[36] Their tentative results, based on the analysis of a clinical sample, pave the path for more informed studies of Schmorl's nodes in past populations, since if this lesion caused pain and disability, it might have affected activity, productivity, social relationships, and morbidity in archaeological populations.

With the exception of the osteomyelitic case, no other infectious conditions have been recorded in the sample. This could be due to the severe erosion of bone surfaces that prevented any such diagnosis, or

Living Conditions and Pollution Levels in 18th and 19th Century Birmingham, England," *American Journal of Physical Anthropology* 132 (2007): 67–79.

31 Brickley, Mays, and Ives, "Skeletal Manifestations."

32 Differential diagnosis of femoral bending deformities also includes Paget's disease. However, although macroscopically a bent bone may resemble osteomalacia, the radiographic and microscopic appearance is quite distinctive. See Brickley, Mays, and Ives, "Skeletal Indicators," 74.

33 Ortner, *Identification of Pathological Conditions* (n. 14 above), 181.

34 Lewis, *Bioarchaeology of Children* (n. 8 above), 138–39.

35 E. Weiss and R. Jurmain, "Osteoarthritis Revisited: A Contemporary Review of Aetiology," *International Journal of Osteoarchaeology* 17 (2007): 437–50.

36 K. J. Faccia and R. C. Williams, "Schmorl's Nodes: Clinical Significance and Implications for the Bioarchaeological Record," *International Journal of Osteoarchaeology* 18 (2008): 28–44.

simply suggestive of fairly good living conditions and nutritional status for the population.

Regarding the possible case of aneurysmal erosion, it must be noted that such shallow depressions are commonly observed on ribs, as bones in general are very sensitive to closely applied pulsating pressure. An extreme case is the effect of long-standing proximity of a large saccular dilatation of an artery (aneurysm) to bone. The internal mammary arteries are closely attached to the posterior surface of the ribs, near the osteochondral junction. In cases of congenital extreme narrowing of the aorta below the left subclavian artery, the internal mammary arteries exhibit marked compensatory dilatation, often producing deep pressure grooves near the osteochondral junctions.[37]

Discussion

In this study, I present the anthropological and paleopathological analysis of a subsample from an early Byzantine cemetery population at Sourtara in northern Greece. The results derived from the first part of the analysis during 2001–2002 are in general agreement with the data obtained from this analysis.[38] For example, no variations are noted in the average age at death or the mortality patterns of non-adult individuals. Similarly, the high incidence of dental diseases is suggestive of a diet rich in sugar and carbohydrates, while the degenerative changes—more frequently affecting male individuals—demonstrates physiological wear and tear on joints due to advanced age.

The bioarchaeological data derived from this analysis add essential information to the generally poor record of the early Byzantine era in Greece, and especially in Greek Macedonia.[39] It is important to emphasize that the multiple and intensive sociopolitical and environmental phenomena of the early Byzantine era highlight the caution with which a bioarchaeological approach must be attempted. Thus, the elements that combine to form the image of a specific site need to be investigated on a case-by-case basis. However, one must bear in mind that adaptation to a continuously changing environment is the key characteristic of life in the past. The complex phenomena of the early Byzantine period had different effects on the populations. In general, two distinctive patterns of adaptation to strenuous conditions can be traced. For some groups, deteriorating living conditions and growing insecurity due to earthquakes and fear of invasions forced the population to abandon their settlement and look for a safer place to start a new life (e.g., Eleutherna and Gortyn).[40] In other areas, despite the hard living conditions of the time, the population appears to have been strong enough to resist a variety of pressures and even to enjoy prosperity (e.g., Messene and Sourtara) until the subsequent centuries (ninth–tenth centuries ad), when cities started to flourish again.[41] Despite the current shortage of comparable bioarchaeological information for proto-Byzantine Greece, future examination of other cemetery populations dating to the same period will help to assess the effects of stress, especially on individuals undergoing active growth.

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37 For a thorough review of aneurysmal erosion and cases attested in the paleopathological record, see Ortner, *Identification of Pathological Conditions,* 357.

38 Bourbou and Tsilipakou, "Human Past of Greece" (n. 7 above).

39 It is only in recent years that a growing interest has been expressed in the study of populations dating to Byzantine and post-Byzantine periods, or of specific segments such as the non-adults. See, e.g., S. J. Garvie-Lok, "Loaves and Fishes: A Stable Isotope Reconstruction of Diet in Medieval Greece" (PhD diss., University of Calgary, 2001); E. Barnes, "The Dead Do Tell Tales," in *Corinth*, vol. 20, *Corinth, the Centenary 1896–1996* (Princeton, 2002), 435–43; P. Tritsaroli, "Pratiques funeraires en Grèce centrale à la période byzantine: Analyse à partir des données archéologiques et biologiques" (PhD diss., Université de Paris, 2006); C. Bourbou, "Infant Mortality: The Complexity of it All!" *Ευλιμένη* 2 (2001): 187–201.

40 Bourbou, *People* (n. 2 above); F. Mallegni, "Analisi dei resti scheletrici umani," in *Gortina*, vol. 1, ed. A. di Vita (Rome, 1988), 339–401.

41 Bourbou, *People.*